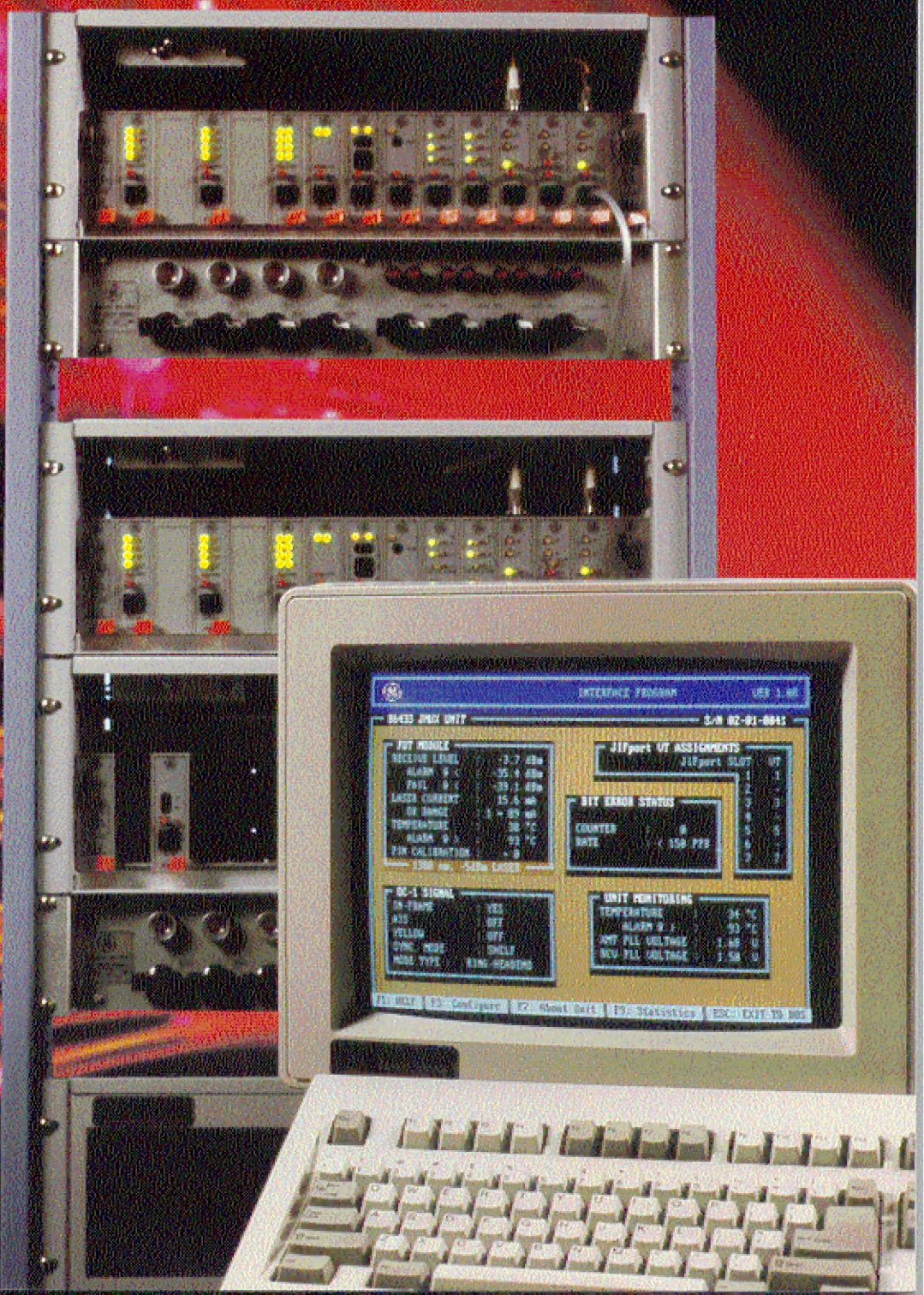
GET - 8368

GE Power Management

FSC FIBER OPTIC SYSTEM COMMUNICATION

APPLICATION GUIDE



DESCRIPTION

The ***FSC*** equipment is a Synchronous Digital fiber optic based system with integrated drop and insert multiplexer and application/interface modules designed for the electric utility industry.

The FSC multiplexer operates at either 51.84 or 155.52 Mb/s rates. The 51 Mb/s system can carry up to 672 DS-0 channels while the 155 Mb/s can carry up to 2,016 DS-0 channels. FSC permits capacity upgrade from 51 Mb/s to 155 Mb/s by simply replacing the optical transceiver modules in the terminal.

The Synchronous Digital standard was first released in 1980's as a joint effort by several standards bodies (CCITT, ANSI, Bellcore, and several vendors). The Synchronous Digital standard is structured in a way to handle payloads for the traditional asynchronous environment DS-0, E-1, E-2, E-3, DS-1, DS-3 and also new payloads, such as Ethernet, FDDI, ATM, etc..

Synchronous Digital telecommunications is becoming the standard of choice for energy industry telecommunication professionals for inter and intra facility communications. The underlying technology is fiber optics. Fiber optics (F/O) has its own inherent benefits which make it the transmission medium of choice:

- F/O has no practical limit to transmission capacity
- Long repeaterless distances, currently up to 70 miles (112 km) @ 1550 nm, are being achieved
- F/O has an inherently low bit error rate (BER), which approaches error free transmission
- F/O has a natural immunity to induced voltages ± ground potential rise (GPR), and electro-magnetic interference (EMI).

Network implementation can be done in stages. A network can be built for today's needs and easily upgraded to meet tomorrow's requirements.

Investments need only to be made when and where it is required.

The FSC system can be arranged to operate in many different configurations, all using the same modular assemblies. This permits easy and cost effective growth and migration between configurations. These configurations include point-to-point terminals, linear add/drop multiplexing, ring plus spurs, and multiple interconnected rings. Ring technology provides redundant paths for application traffic to maintain service if a fiber optic or electronic failure occurs.

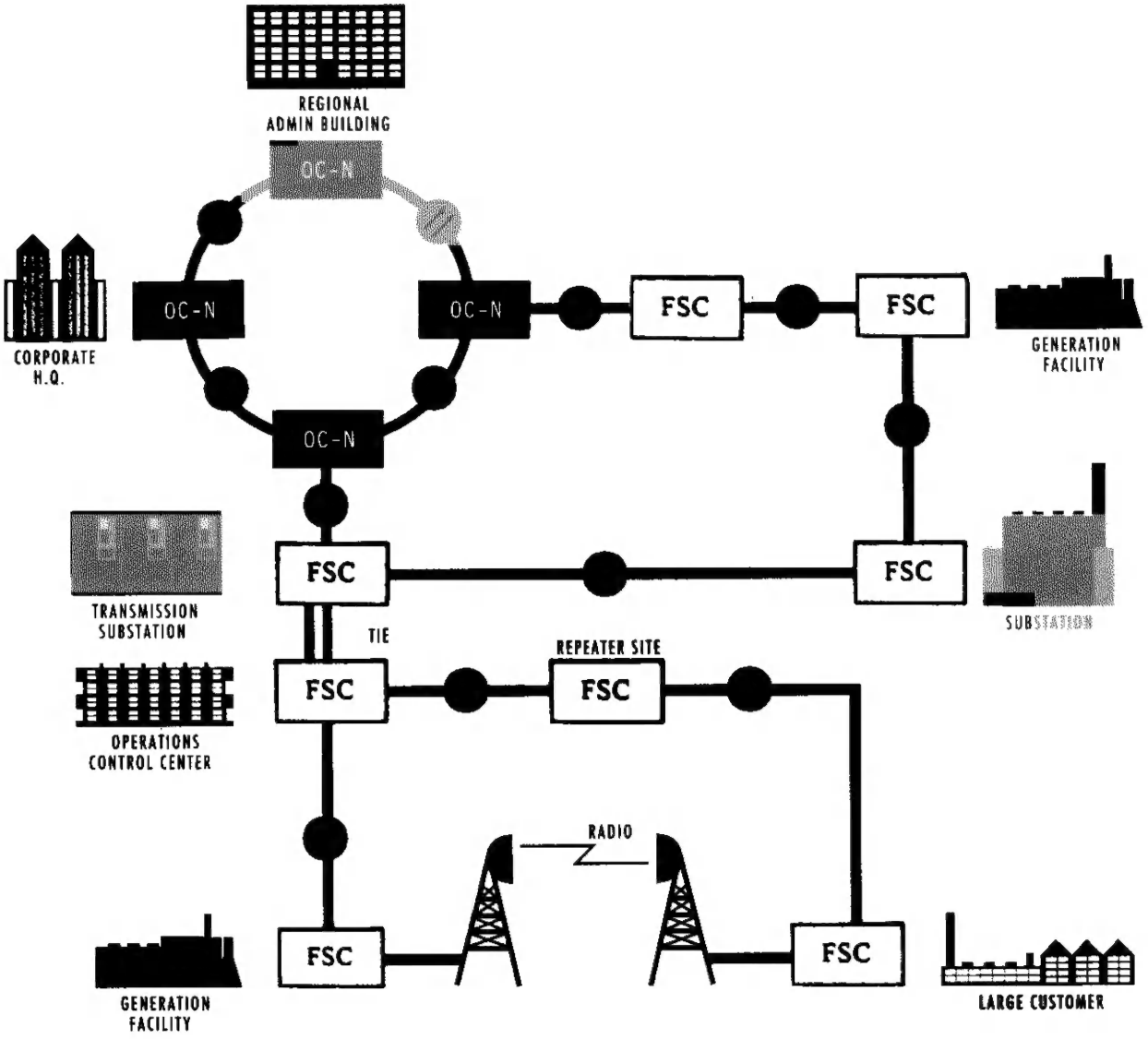
Access to individual DS-0 application circuits is possible without having to go through staged asynchronous multiplexing DS-0, DS-1, DS-3 or E-1, E-2, E-3. Investment on a per site basis, specially where add/drop are small, is more controlled with fewer places for malfunction.

Ring switching times are specified as <50ms by by the Synchronous Digital standard. GE's FSC is capable of < 3 ms ring switching time, which greatly improves the system availability.

The modules for the system common equipment as well as the application specific units are designed to meet IEEE/ANSI SWC specifications for surge and transients as well as IEEE/ANSI RFI standards for RFI.

Because the FSC system is Synchronous Digital based, it takes advantage of the inherent network management capabilities provided by the standard's overhead bytes. The FSC Network Management System allows for the network visibility down to the individual DS-0 level at every node, remote provisioning (configuration and monitoring) of the network from any node, alarm logging and manual path switching. This is done via a DOS/Windows based personal computer which can be used for system diagnostics and trouble-shooting. The FSC also provides both local and express order wires as defined by Synchronous Digital standards, thus providing internodal communications for system commissioning, alignment, maintenance and troubleshooting.

F/O RING APPLICATION



APPLICATION

The FSC is a fiber optic telecommunication multiplexer. Essentially, multiple applications can be added/dropped at each terminal. Transmission between terminals occurs via fiber optic cable. Multiple traffic circuits from teleprotection to RS232 to Ethernet can be carried over the same fiber optic strand.

The FSC's design is "hardened" to meet specification requirements of the power utility substation and generation facility environment. SWC, EMI, RFI, High Pot, and temperature (-20 to 60 degrees C) specifications are built into the equipment design to permit ultra-secure operation in these most hostile of situations.

Many different fiber optic cabling topologies are supported by the FSC product architecture.

Ring topology provides geographical route diversity, should a cable be cut, or an optical transceiver or terminal fails. In the two fiber ring implementations, two fiber strands within a cable are used to transmit the same information simultaneously in both directions around the ring.

Multiple interconnected rings permit traffic exchange between two separate ring networks. This type of topology is sometimes selected to conserve the overall transmission bandwidth since much of the telecommunication traffic can be contained within each ring, with only a small amount passing between the two rings. It also permits a degree of security and availability improvement for the traffic in each ring (i.e., whatever happens to the fiber cable in one ring, will not affect the continued redundancy protection in the other ring).

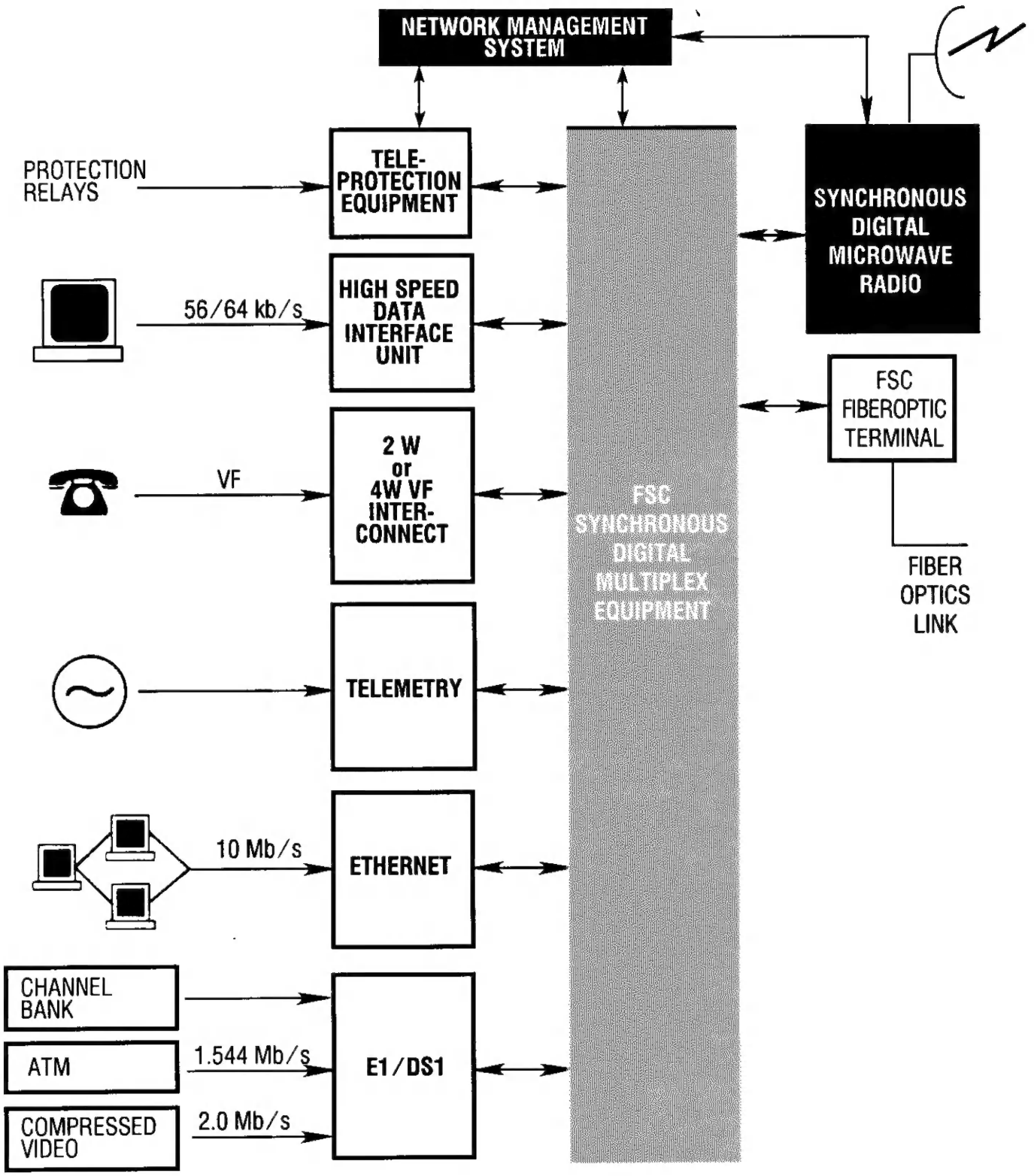
Flattened rings provide ring redundancy functionality without the geographical route diversity protection. Four fiber strands are used within the same cable.

Multi-mode or single-mode fiber cable are both supported with the same FSC optical transceiver. Single-mode essentially can be used for longer distances and higher bandwidths than multi-mode.

Each FSC terminal can be customized with the insertion of required application modules into the shelf (and expansion shelves)

A variety of application circuits have been designed at this point, with more under consideration. Each FSC can be equipped with any number of:

- **Digital Teleprotection** - trip commands are wrapped in coded signals for high reliability, availability, and almost non-existent false trips.
- **Pilot Wire Relaying** - older pilot wires from HCB, CPD, SPD can have their relay schemes taken off copper cable and placed on fiber.
- **2 Wire and 4 Wire Voice (audio) Circuits** - 2W voice is typically used for remote extensions from a PABX (connection to public switched network). 4W voice is used for the same purpose, to connect PABX, and also used for analog relay communications.
- **Low Speed Data** - 2.4 Kb/s, 4.8 Kb/s, 9.6 Kb/s, 19.2 Kb/s and 38.4 Kb/s are various data rate RS232 signals that can be transmitted. Typically used for SCADA RTU polling and connecting various instruments.
- **High Speed Data** - these types of data circuits are often used by relays, instrumentation and slow video surveillance.
- **Analog Telemetry and Digital I/O** - these types of sensory information are transportable and permit real-time communication of values.
- **E-1** *(T-1 at 1.54 Mb/s or E-1 at 2 Mb/s)* - these types of interfaces are typically used for channel bank connection, PABX trunks, and compressed video circuits.
- **Ethernet** - multiple Ethernets can be transported. These 10 Mb/s signals are typically used by Programmable Logic Controllers (PLCs) and computer control systems (substation automation).
- **Orderwire** - party line voice circuit for FSC and site maintenance purposes. All connected FSC terminals can have party line audio communications.


NETWORK MANAGEMENT SYSTEM
PROTECTION RELAYS
TELE-PROTECTION EQUIPMENT
SYNCHRONOUS DIGITAL MICROWAVE RADIO
56/64 kb/s
HIGH SPEED DATA INTERFACE UNIT
FSC FIBEROPTIC TERMINAL
VF
2 W or 4W VF INTER-CONNECT
FSC SYNCHRONOUS DIGITAL MULTIPLEX EQUIPMENT
FIBER OPTICS LINK
TELEMETRY
10 Mb/s
ETHERNET
CHANNEL BANK
ATM
COMPRESSED VIDEO
1.544 Mb/s
2.0 Mb/s
E1/DS1

SYSTEM CONFIGURATION

The open architecture of FSC provides maximum flexibility for network modification and growth. New features and interfaces are easily integrated with existing systems. Due to the broadband Synchronous Digital capacity, additional circuits are easily turned up by just plugging in the new interface units and expansion shelves, as required.

FSC SHELF ASSEMBLIES

All FSC shelves meet standard 19" EIA rack mounting characteristics.

The Common Equipment Shelf; "FSC1S" - is a 7" high (4 RU) which houses up to 15 plug-in units. This is the initial shelf for each node and will contain one or more JMUX *(one JMUX per fiber direction)*, JIF, Service, and Power Units, plus various channel units. The upper half of this shelf is dedicated to storing loose fiber patch cords or pigtails and to protect the vertically mounted fiber optic connectors on the JMUX Unit(s).

The Channel Equipment Shelf; "FSC2E" - is also 7" high and acts as an expansion shelf for additional FSC plug-in units. One or more shelves are typically mounted directly below the Common Equipment Shelf, as necessary. Interconnections between shelves are made in a "daisy-chain" fashion with balanced cabling.

A terminal node can be easily converted into a add/drop node by adding the necessary plug-in units. Thus, the same Common Equipment and the Channel Equipment Shelves can continue to be used.

JMUX UNIT

The JMUX Unit (or Synchronous Digital multiplexing unit) - provides the transmit and receive optical interfaces to the fiber optic cable. It converts these optical signals to electrical signals, recovers the clock signal from the incoming data stream, allows Service Unit access to Synchronous Digital overhead bytes, and also provides interfaces to allow local channel units access the synchronous data stream.

JIF UNIT

The following types of JIF Intermediate Format Units are available for network applications:
The JIF, JIF-E1, JIF-DS1, and the JIF-TIE.

The JIF Unit accepts one JIF Port from the JMUX Unit and de-multiplexes traffic to three shelf buses. The JIF Unit also provides the important feature of path protection switching. In the ring configuration, two JIF Units operate as an interlocked pair and select which incoming signal path will be fed to each bus.

The JIF-E1 Unit - integrates the JIF and E1 Channel Unit functions together into a common plug-in unit, simplifying the product packaging for applications that may only have E1 interface requirements. The units can accomodate up to three E1 signals (E1 or DS1 models available).

The JIF-TIE Unit - accepts any input from a JMUX Unit (JIF port) and hands them off to a spur or another ring.

All of the above types of JIF Units offer both equipment redundancy and path protection in system ring configuration.

SERVICE UNIT

Each node has a Service Unit for providing a variety of support functions. This unit can also be considered the heart of the FSC System's network management capabilities and provides:

- Monitoring of all equipment alarms from individual units
- Major and minor office alarm relays, plus ACO button
- Face Plate LEDs for visual monitoring of alarm status
- CI (Craft Interface) for node configuration, access to shelf monitoring and diagnostics of the entire network
- Several user-assignable auxiliary multi-point data channels
- TBOS (E2A) interface allowing external porting of network management information

Each node in the network is equal in status. Any site can be considered "master". The system has

been designed to allow each node to monitor its own node's alarm and status information, plus alarm and status information of all other inter-networked FSC nodes.

DIGITAL RELAYING CHANNEL UNIT

The Digital Relaying Channel Units (DRC *transmitter and receiver pairs)*, provide an isolated interface for each of four independent transfer trip, or line protection circuits, to be carried over a single DS-0 channel of a FSC system. Typical trip response time is 2 milliseconds.

The DRC circuits can be configured for the traditional trip and guard operation for direct replacement of analog tone equipment. They use a digital time division multiplexing scheme to transmit the trip data. This allows the four circuits to be completely independent.

All four circuits can operate simultaneously without affecting the dependability and security of the other circuits. A dual CR-16 error detection code assures freedom from the false trips. Enhanced dependability is provided through circuit source-destination address matching and continuous self testing capabilities.

Optional test panels are offered to allow end to end testing and verification of the transfer trip circuits, while incorporating interlocks to prevent accidental tripping.

The test panel allows for testing of main and auxiliary keying loops, and the output drivers, for the four separate channels on the DRC transmitter and receiver units.

CURRENT DIFFERENTIAL RELAY UNITS

This unit provides the direct replacement of conventional protective relay pilot wire circuits with a fast digital communication link. The end-to-end delay requirements are acheived by utilizing four DS-0 (64 Kb/s) FSC channels.

Substituting the pilot wire circuit with a fiber optic link demands a near perfect replication of the pilot wire signal to preventing false tripping at the remote current differential relay. The FSC CDR Unit uses 10 bit quantization every 80 microseconds to sample the current differential relay output with 0.1% resolution and send it over a 192 Kb/s channel (3 DS-0s) to the remote relay. This results in a faster and more accurate replication then can be produced by single DS-0 carrier products.

There are a variety of relay interface units offered to interface with different current differential relays (HCB, HCB-1, CPD, SPD, RADHL, SLD, etc.).

The FSC module provides all the necessary functions for the A/D conversions as well as providing an independent Digital Relaying Channel (DRC). This module emulates the conventional pilot wire link by providing the same voltage, current, and impedance to the current differential relays. The software embedded in this module supports an end-to-end test facility (local and remote) and therefore, no external test panels are required.

TWO WIRE CHANNEL UNIT

The 2W Foreign Exchange Office end (2WFXO) channel provides the voice frequency (VF) and loop signaling between the FSC common equipment and a FX trunk with ground start signaling or FX lines with loop start signaling.

The 2 Wire Foreign Exchange Station / Private Line Automatic Ringdown (2WFXS/PLAR) channel unit provides the VF and loop signaling interface between FSC common equipment and a 2 Wire Foreign Exchange Station end or PBX trunk circuit. This unit supports ground start as well as loop start applications. When configured as PLAR, it can be used as a non-switched Private Line Automatic Ringdown application.

This module occupies a single DS-0 (64 Kb/s) time slot in the FSC system and can plug into any application module slot in a FSC shelf.

FOUR WIRE VF CHANNEL UNIT

This channel unit provides one or two (option dependent) independent 4W VF circuits as the interface between a VF trunk and the FSC common equipment. Each circuit occupies a single DS-0 (64 Kb/s) timeslot in the FSC system and can plug into any application module slot in the standard FSC shelf.

The various 4W VF channel units can be used in the following modes of operation:

- 4W E&M to interface the FSC system with a 4W VF trunk, that uses type 1-5 signaling.
- 4W TO (transmission only) to interface the FSC system with 4W VF circuits, that do not require E&M signaling. A typical application is for a VF trunk that uses in-band signaling.
- 4W E&M/PLR in a pulse repeater mode for applications that require a back-to-back connection with another E&M channel unit.

LOW SPEED DATA UNIT

This unit provides up to 4 full duplex asynchronous data circuits with 8 end-to-end RS232 control signals over a single DS-0 (64 Kb/s) timeslot in the FSC system. It can plug into any application module slot in a standard FSC shelf.

The Low Speed Data unit provides sub-rate multiplexing of 4 data streams, each up to 9.6 Kb/s, or two 19.2 Kb/s, or one 38.4 Kb/s. This unit behaves like a virtual wire and provides transparent data transmission independent of baud rate, and the number of start, stop, or data bits.

HIGH SPEED DATA UNIT

This unit provides a single high speed data channel in conjunction with end-to-end RS422 or V.35 control signals. The unit occupies a single DS-0 (64 Kb/s) timeslot in the FSC system and can plug into any FSC shelf.

The High Speed Data Unit is software configurable to operate at 64 Kb/s synchronous or 56 Kb/s synchronous and asynchronous modes of operation. The unit may also be configured via software as either DCE or DTE.

ANALOG TELEMETRY CHANNEL UNIT

These units interface to the FSC system by using one single DS-0 (64 Kb/s) FSC channel and support two or four (depending on the option) analog telemetry circuits.

The Analog Telemetry Unit (ATU) transmitter senses a current or voltage at one site and the ATU receiver reproduces that current or voltage at another site utilizing the FSC as the transport system.

The ATU embedded software allows all the inputs and outputs to be monitored (on a PC) with five digits resolution. It also provides voltage/current conversion as well as range conversion at the ATU receiver output.

E-1 INTERFACE UNIT

The E-1 Unit provides the necessary interface between the FSC common equipment and three independent E-1 data streams. The E-1 data streams are transparent to this interface. A pair of E-1 Units provide the 1:1 protection switching of each of the three E-1 signals independently.

This module supports the add/drop of up to three E-1 circuits. There is a maximum of 14 E-1 circuits that can be transported in a 51.84 Mb/s payload. A 155.2 Mb/s FSC system can transport 42 E-1 circuits. A maximum of 12 E-1 circuits can be dropped/inserted at any one FSC terminal. A DS-1 51.84 Mb/s interface unit is also available, which interfaces up to three DS-1 circuits.

ETHERNET BRIDGE UNIT

This unit provides a single 10 Mb/s Ethernet interface to allow LAN connection between two FSC nodes. This unit effectively connects together local LANs to form a single large Ethernet network (Ethernet WAN)

The Ethernet bandwidth can be adjusted between 1.54 Mb/s up to the full 10 Mb/s native rate. This permits total bandwidth conservation in situations where the full 10 Mb/s is not required. Multiple Ethernets can be run over the same FSC system (i.e., four 10 Mb/s Ethernets can be transported over a 51.84 Mb/s FSC system).

When ring topology is being used, two Ethernet Units are required at each site for each Ethernet connection. Each packet from an Ethernet LAN is propagated in either or both directions around the ring network. These packets will incur unique propagation delays around the network. The destined site implements a packet resolution function to only broadcast a single packet to the local LAN. In the event of a fiber failure on a preferred path, the Ethernet Bridging Unit will recognize that sites are no longer visible over the preferred path and will redirect traffic over the alternate route.

TECHNICAL SPECIFICATIONS*

Optical Interface: (51.84 Mb/s)
Connector: FCPC
Wavelength: 1300 nm or 1550 nm
Type of Fiber: Singlemode or Multimode
System Gain: (Singlemode fiber)
@ 1300 nm: 30 dB (70 km typical span)
@ 1550 nm: 35 dB (110 km typical span)
Source: Laser

Electrical Interface: (51.84 Mb/s)
Connector: BNC
Type of Cable: Coxial, 75Ω
Transmit Power:
per TR-NWT-253 Bellcore Standard

Capacity: (51.84 Mb/s)
672 Channels (DS-0)
Line Rate: 51.84 Mb/s
Line Code: NRZ

Optical Interface: (155.52 Mb/s)
Connector: FCPC
Wavelength: 1300 nm
Type of Fiber: Singlemode
System Gain: (Singlemode fiber)
@ 1300 nm: 30 dB
Source: Laser

Capacity: (155.52 Mb/s)
2016 Channels (DS-0)
Line Rate: 155.52 Mb/s
Line Code: NRZ

Configurations supported:
Unidirectional Path Switched Ring per Bellcore TR-TSY-000496
Two Fiber Linear Systems
Multiple 155.52 Mb/s Rings plus Spurs
Multiple 155 Mb/s, 51 Mb/s Rings through Tie

Synchronization:
Internal:
Internal Clock @ Headend node:
±20 ppm Line Timing @ any other node per Bellcore Standard
External:
System can be Synchronized to an External BITS Clock (e.g. Stratum 1)

Network Management Capabilities:
Network Visibility at Every Node, Remote Provisioning (monitoring and configuration) of the Network
Alarm logging and Time Stamping
Manual Path Switching

System Alarms:
Major:
Form C Alarm Relays and LED Indicators
Minor:
Form C Alarm Relays and LED Indicators

Orderwire:
64 Kb/s Channel Carried in either Transport Overhead or Path Overhead

Channel Interface Units:
LED Status Indicators
Teleprotection Units have Form C Alarm Relays

Node Through Delay:
14 µs (51.84 Mb/s)
20 µs (155.52 Mb/s)

Protection Switching Rate:
< 3 ms

Connectors:
Screw Type Terminal Blocks for All Interface (Channel) Units, Power and Alarm Relay Connectors

Power Requirements:
24.48, 125 Vdc or 115 Vac

Consumption:
10 W for Add/Drop Node Common Equipment (For Individual Channel Unit Power Consumption Refer to the Technical Data Sheet for that Unit)

Diagnostics:
RS232 Craft Interface, Front Panel RJ11 Jack Running @ 9600 baud at Every Node for System Diagnostics, Monitoring, Configuration, Troubleshooting and Maintenance

EMI/RFI:
Meets ANSI/IEEE C37.90.2 RFI

Isolation:
Meets ANSI/IEEE C37.90.1 SWC

Reliability:
(Per Bellcore TR-NWT-000332)
Ring System (common equipment)
MTBF: 130,000 hours
Linear System (common equipment)
MTBF: 50,000 hours
Interface Units: For Individual Interface MTBF Figures, Refer to the Unit Interface Technical Data Sheets

Environmental:
Operating Temperature:
-20° to +60°C (-4° to +140°F)
Storage Temperature:
-40° to +70°C (-40° to +158°F)
Humidity:
5 - 90% non-condensing
Shipping Altitude:
15,000 meters (50,000 feet)
Shock and Vibration:
Vibration (transit) per MILS-STD810E
Bench Handling per TS-1-00446.06

Physical Data on Shelves: ***Common Equipment and Channel Unit (Expansion)***
Height: 178mm (7 inches)
- Four Rack Mounting Spaces (RMS)
Width: 483mm (19 inches)
Depth: 260mm (10.25 inches)
Weight: 3.35kg (7 lbs.-4oz.)

Electrical Characteristics for Application Specific Interface (Channel) Units:

Digital Relaying Input:
Four, opto-isolated, 10 mA Input Current with optional dual keying loops

Digital Relaying Output:
Four Outputs, Two Solid State Relay Contacts at 5 Amp, 150 V per Output

Current Differential Interfaces:
HCB, HCB-1, CPD, SPD, RADHL and SLD Relays

4W-Voice Interface: Standard
600/900 ohm 4W Interface with Optional E&M Signal Operating at Standard TX/RX Levels

2W-Voice Interface: Standard
600/900 ohm 2W Interface with Optional E&M Signal Operating at Standard TX/RX Levels

2 Wire FXO and FXS Interfaces:
Loop Start or Ground Start Signaling to the Office and Subscriber

Low Speed Data Interface:
(Asynchronous) RS232 Interface, up to Four 9.6 Kb/s or Two 19.2 Kb/s or One 38.4 Kb/s

High Speed Data Interface:
(Synchronous / Asynchronous)
RS422/V.35 Interface, 56 Kb/s or 64 Kb/s

DS-1 Interface:
(Asynchronous) Up to Three Standard 1.544 Mb/s T-1 Interfaces

Ethernet Interface:
10 Mb/s Ethernet Bridge per IEEE 802.3 Standard.
Operates with External Interface to Provide the Appropriate Interface for Twisted Pair or Coaxial Cable

Analog Telemetry Interface:
Four DC Analog Inputs with Unipolar or Bipolar Ranges

FDM Interface:
Transport of Supergroup (60 FDM Channels)

E-1 Interface:
(Asynchronous) Up to Three Standard 2.0 Mb/s E-1 Interfaces

GET-8368

* Refer to GEA-12566 through GEA-12577 for individual Unit Data Sheets and ordering information

Malvern, Pennsylvania,
in Philadelphia's high-tech corridor,
Headquarters for GE's Protection and Control Business

Continuing Investment in the Future

Here, GE engineers and technical personnel are positioning resources for power system protective needs into the 21st century through continued investment in sophisticated tools and product development programs. Research and development programs provide a continuing flow of new protective relays and utility communication systems incorporating the innovative ideas and new technology that have characterized GE's leadership in the field of system protection throughout the 20th century.

GE Power Management

UTILITY SALES
205 Great Valley Parkway
Malvern, PA 19355 USA
Tel.: 610-251-7000
Fax: 610-251-7101

INDUSTRIAL SALES
215 Anderson Avenue
Markham, Ontario, Canada L6E 1B3
Tel.: 905-294-6222
Fax: 905-294-8512

http://www.ge.com/edc/pm

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